Loudspeaker Solutions for Worship Spaces

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Sound systems for worship spaces can be a delight for all listeners or the horror of the millennium. The loudspeaker system performance can decide between the two.

Nearly all of our worship centers require amplified sound. For a half a century, loudspeakers have been installed in worship centers to provide loudness and clarity for the spoken Word. With the introduction of contemporary music formats as part of the worship experience sound systems for churches have had to expand to accommodate the amplification of choirs, soloists, orchestra instruments, pre-recorded music, and electronic keyboard and other musical instruments.

Loudspeaker systems used for the worship space have evolved over the last 50 years. Technology advances have been driven by the increasing demand for more power and greater fidelity in music amplification. Worship centers have been growing in size and must fulfill a variety of uses. Many churches today use the same space for worship, fellowship, and athletic activities. These aspects of contemporary worship space use require sound system and loudspeaker equipment that can meet the technical demands and congregational expectations for great sound. This article will present current advances in loudspeaker technology and how they can be applied to the worship center environment.

Read more about Electro-Voice® fixed installation speakers.

Why loudspeakers at all?

Here is a common question: “When we first built the church 80 years ago, we did not have a sound system and everyone could hear fine. We have spent thousands of dollars on sound equipment and none of it has worked as promised. Why do we need to spend more money now?”

The answer to the above question is simple: “They could not always hear before, they didn’t have a sound system, and you either bought the wrong stuff or it has not been operated properly.”

The real answer is that sound systems are required for speech amplification to overcome acoustical characteristics of large gathering spaces. If a large room meets certain acoustic criteria, un-amplified speech can be heard clearly at all seats. Unfortunately these criteria are not always present.

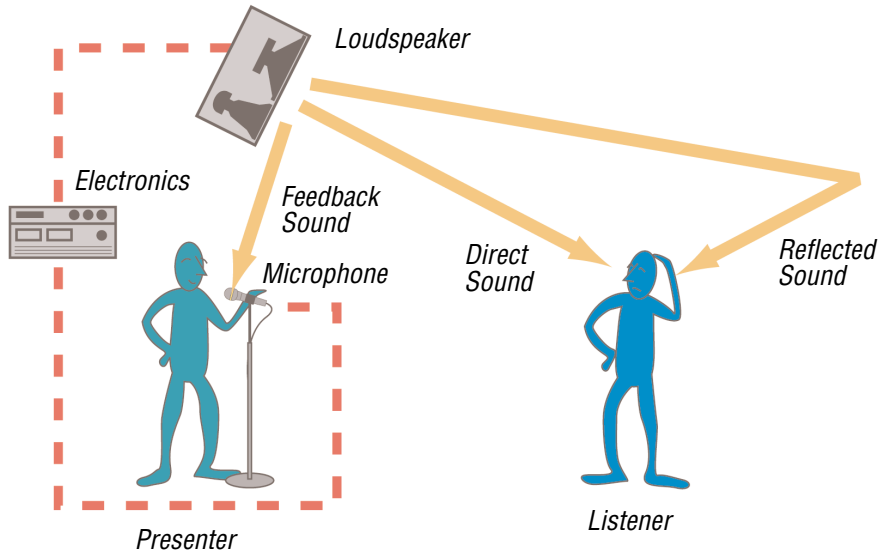
- *Quiet background noise:* Possible before air conditioning and traffic passing by.
- *Trained public presenter:* Possible when only one person was the "preacher".
- *Reverberation optimized:* Happens only with careful architectural design.
- *The room directs sound energy to the congregation without causing echoes:* This is possible in smaller rectangular shaped rooms (300 seats) but not in most large, fan shaped, round rooms, octagonal rooms, etc.
- *No electric guitars or drums*.

It is unlikely that your worship space meets all of the above criteria. So let's see what sound systems are suppose to do and how they can make speech clearly heard by all listeners, amplify music with full fidelity, and not fail when driven at loud sound levels.

Sound System Components: What do they do?

The following figure shows the basic sound system components including the room.

The presenter speaks into the microphone, which converts sound energy into an electrical signal. That signal is processed and amplified to drive a loudspeaker. When the sound is emitted from the loudspeaker (and from the presenter for that matter) it radiates in many directions and decreases in



level the farther it goes. Some sound travels a direct path to the listener (direct sound.) Some reaches the listener only after reflecting off one or more room surfaces (reflected sound.) Some of the loudspeaker sound radiates toward the microphone (potential feedback sound.)

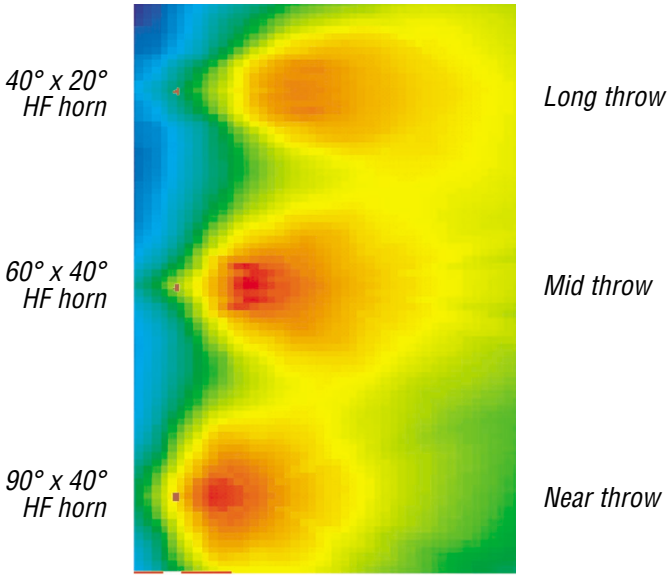
Direct sound with no reflections produces the greatest clarity. Reflected sound can be beneficial by adding loudness and "space" to the sound but can also obscure speech intelligibility and musical articulation. The feedback sound causes trouble because when it reaches the microphone, it is amplified and radiated again from the loudspeaker—over and over—until a howling pitch is heard. The presence of the howl is called feedback. The specific pitch of the howl is determined by the distance to the loudspeaker and surrounding reflecting surfaces, so the exact pitch will be unique for every microphone location. There are also many howl pitches for each condition. But in general, the howl pitch will be whichever frequency is loudest at the microphone. The feedback sound limits the loudness level at which a sound system can be operated. The ways to reduce the destructiveness of feedback is to 1) move the microphone closer to the presenter, or 2) reduce the level of feedback sound by moving the loudspeaker closer to the listener and farther from the microphone, or 3) by using high quality directional microphones, or 4) by using a directional loudspeaker that radiates most of its sound to the listener and away from the microphone. Directional loudspeakers can also be used to direct energy away from the room walls and ceiling and concentrate the sound into the congregational seating. Of course, the big questions are: "what are directional loudspeakers?" and "which one is best for my application?"

Loudspeaker directivity is the ability to direct the sound energy only in a specified direction. This is achieved by using a horn or an array of cone drivers. Horn loudspeaker directivity is specified by the angles over which the horn operates. If a horn will cover 90 degrees in the horizontal plane and 40 degrees in the vertical place, then it is a 90º x 40º horn. The next figure shows what this means to radiating sound on the congregational area. Three different patterns are shown. The maps are computer generated and represent the equal loudness areas (red to yellow) for a loudspeaker mounted near the ceiling of the room and directed to spot pointed on the floor. Green areas would be about half the loudness of the other areas. Notice that the more narrow the pattern the further the sound can project or throw.

This characteristic of horns allows them to be used in loudspeaker arrays, where the array coverage is tailored to match the congregational seating. Wide coverage horns are used for the front seating areas, and mid or long-throw horns are directed to the farther seating areas. Horns usually only

Read more about EV® FRX speakers:
FRX-122
FRX+ 181
FRX+ 640
FRX+ 660
FRX+ 940

operate over the higher frequency range and cone "woofers" are used for the low frequency ranges. Careful application design through computer-aided



sound system design programs allow precise mapping of coverage of the horns to the seating while minimizing the sound spill (and feedback) to stage microphones and reflections from walls and ceilings.

As sound waves get longer, their pitch frequency goes lower. In order for horns to be effective in their directivity control, they must be large compared to the lowest pitch frequency. High frequency horns that can work from speech articulation frequencies need to be at least 12" high. Mid range horns that can control the fullness of male speech need to be at least 30" high, and bass horns can be as large as 72" tall to be fully effective. The more directivity control that can be applied to a loudspeaker array, the better the perceived clarity and music detail. Detail brilliance, choir articulation, speech intelligibility, punchy bass, presence and warmth are all related to the ability of the sound system loudspeakers to provide directional control to the audience at all musical pitches.

The same dimensions hold true for arrays of cone drivers. The taller the array of cone loudspeakers, the better able it is to control the low frequency directivity. Unfortunately, real low frequency control requires tall bass loudspeakers arrays and large horns. If your building can architecturally accept a 10-foot-high loudspeaker array and your budget can cope with the expense then there is no problem. But, what about the rest of us with low ceilings and small budgets?

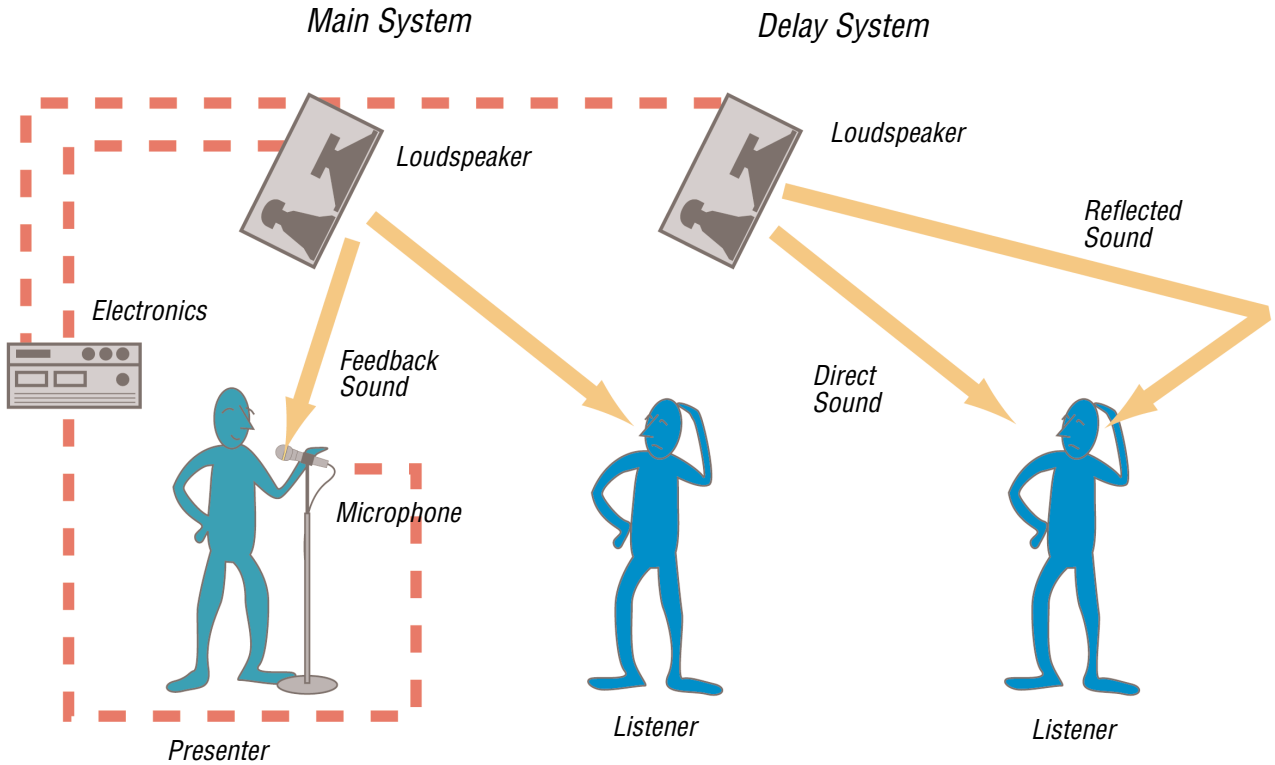
Digital Signal Processing saves the day!

Large loudspeaker arrays just can't fit in every space. One solution is to let the smaller systems cover what they can and then just add some more for additional coverage. After all, as long as the sound gets to the seats and not the microphone and the walls we can still have a happy congregation. The only problem is that sound travels slowly. For the sound from the loudspeaker to travel to a listener 60 feet away will take nearly 0.05 seconds. Pretty fast you say. Well if we have another loudspeaker nearby at 10 feet away we will hear it well before the distant main loudspeaker. Now the sound will feel like is comes from the close loudspeaker and the main loudspeaker will sound like an interfering echo. The following figure shows the situation.

Read about the Dx38 and ACOne signal procesors.

The second loudspeaker is called the delay loudspeaker because its sound has to emerge later than the sound of the main loudspeaker system. This delay time is critical for synchronizing the two sounds so they arrive at the listener at the same time, sounding natural with no echo.

Digital signal processing (DSP) changes the audio signal to a digital signal, delays it for a while, and then changes it back into an audio signal. This



provides an important advancement in the performance of sound systems. DSP cannot only add delay but is also capable of adjusting the tone (equalization), limiting the loudness, act as crossovers, and even find and tune out feedback pitches. The application of DSP devices to loudspeaker systems gives the sound system designer the opportunity to use many different combinations of loudspeakers to provide fidelity and coverage for optimum sound in the worship environment.

Loudspeaker types: How do I know which one is correct for my room and where does it go?

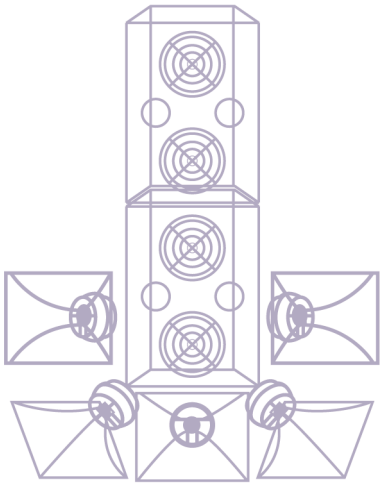
In the last decade, the art and science of loudspeaker system engineering has rapidly moved forward. Engineers have created systems with precise directivity control over wide frequency ranges, very low distortion, and high sound level output. Advancements in materials allow loudspeaker enclosures to be made of lightweight materials for convenience in portable applications and versatility in fixed installed environments. DSP processing of the horns and cones of multi-driver system provide optimized fidelity. Loudspeakers for live sound amplification can now have performance that rivals the highest fidelity systems for home, studio, or automobile use. The trick for live sound is to apply the correct system for your seating geometry, acoustic environment, and production requirements. Worship centers usually require specific systems for the particular job the loudspeaker must do. Contemporary worship with amplified music usually requires the following loudspeaker systems:

Main Center Cluster: This loudspeaker is usually mounted on the ceiling above the center front of the chancel platform. Its purpose is to provide clear speech amplification to every seat in the congregation. The coverage and directivity must be precise and not cause feedback by directing sound to the main speech microphones. This system usually consist of a custom engineered loudspeaker array that uses high frequency horns to direct the energy to specific areas of the seating plains. Low frequency cone systems are used to provide bass energy to the sound and when applied in vertical arrays can provide low frequency directivity control.

Fill systems: Often, the main loudspeaker cluster cannot reach all of the seats because of architectural obstructions like ceiling slopes near the loudspeakers, and balcony rails and overhangs near the audience. Small systems with combinations of horn and cone drives can be use in the areas with DSP delays to fill in were the main system couldn't reach.

Read about FRX Series and Xi Series speakers:
Xi-1082
Xi-1123/106
Xi-1152/64
Xi-1152/94
Xi-1183/64
Xi-1191
Xi-2153/64
Xi-2181

Read about FRi+/FRi Series and EVID™ speakers.



Component array

Stereo Amplification: Music performance benefits from stereo amplification to provide spaciousness, depth and "air" to amplified instruments. We hear stereo all the time on home music systems, TVs, and cinemas. Why not during worship? The center cluster can be supplemented with left and right channel stereo systems placed either side of the chancel platform. These systems are used to enhance the amplification effect. They need to be powerful with low distortion and wide coverage patterns. For large spaces, three-way systems (low, mid-range, and high frequency) are indicated for this application.

Read about CPS amplifiers.

Subbass: Nothing gets music going with fidelity and warmth like lots of bass. Producing low distortion bass energy for large spaces requires lots of big loudspeakers. 18" cone drivers in large boxes are most suitable for this application. Because they are used only on the lowest of tones where we cannot hear direction very well, the sound designer has great leeway in their placement. By using a dedicated subbass array, the main systems can be reduced in size and suspended from the ceiling and the heavy subbass systems can be place on the floor, hidden under the chancel platform, or in organ tone chambers.

Choir platform: The choir has to hear too! The choir likes to hear preaching, piano, sound tracks, soloist, etc. Loudspeakers for the choir can be portable systems to allow flexibility, small loudspeakers distributed between or on the back or the choir chairs, or compact horn/cone systems mounted over the choir. They will need their own control and mix from the control console to

keep choir amplification microphones out of the choir loudspeaker. Remember: pointing the loudspeaker at the front of the microphone will cause feedback. If the microphone is a "cardioid" type, a reasonable amount of sound will be rejected at the rear of the microphone and will not cause feedback.

Stage monitors: On stage, performers will require portable loudspeaker systems directed at them to allow them to hear other musicians and themselves. Feedback from floor monitors is not usually a problem if the soloist sings "right on the mic" (lips touching the mic). The louder the music, the more powerful the monitor must be. Stage monitors usually require their own amplification control from the mixing console. Musicians being the way they are will want a sound different than what everyone else will need.

Read about Electro-Voice stage monitors.

The modern worship space—with its varied uses, performances, and production requirements—needs a wide variety of loudspeaker types. The correct use of components, packaged systems, and portable systems allow the church sound person the opportunity to put high quality sound right where it needs to be.